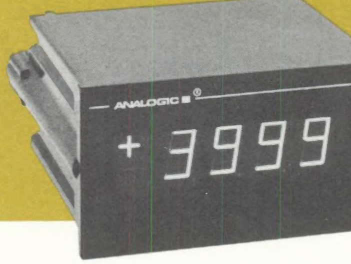


AN2559

UNIVERSAL, BIPOLAR, LINE-POWERED 3 3/4-DIGIT (± 3999-COUNT) DIGITAL PANEL INSTRUMENT

The Analogic AN2559 is the first, value-added, 3¾-digit, 3999-count DPI featuring built-in versatility and flexibility. It comprises a basic, universally powered digital panel instrument with standardized connectors into which an ever-expanding library of special- and general-purpose plug-in PC cards can be readily field-inserted and interchanged without any DPI modifications. Consequently, a single AN2559 can accomplish custom or standard analog input signal conditioning and digital output interfacing to fulfill a seemingly unlimited range of commercial, industrial, and laboratory instrumentation applications. By stocking only the AN2559, most OEM users can satisfy all of their 3¾-digit DPI requirements.

Versatility in the AN2559 includes an internal power and signal interface connector that accepts a general-purpose plug-in card upon which the user can install proprietary analog-interface circuits, or Analogic can add special-purpose circuits during manufacture, whichever is more economical. Typical analog-interface functions that can be provided are: ac and dc current measurements, extended range ac and dc voltage measurements, active multipole filtering, optimized signal filtering, thermocouple or RTD temperature transducer conditioning, LVDT excitation and demodulation, frequency-to-voltage conversion, current sourcing, auto-ranging, and very high impedance buffering. All with ±3999-count resolution.

Power and space are provided in the AN2559 to accommodate an optional digital circuit card for such value-added features as isolated and/or buffered parallel BCD outputs, digital linearization, and set-point control. Again, these features can be incorporated by the user, or for OEM quantities, engineered and installed by Analogic. Since the basic AN2559 design is so widely flexible and adaptable, it decisively offers more value-added application possibilities than any competitive DPI.

Performance characteristics that contribute to the wide-range versatility of the AN2559 include: a true, differential front end; dual-slope, long-period signal integration; choice of bright, luminous 0.55" (14mm) gas plasma or 0.43" (11mm) LED display; common-mode and normal mode rejection ratios of 160 dB and 100 dB, respectively; and a universal 100, 117, 220, and 240 volt ac power transformer.

Exceptional confidence in the high quality and reliability of the AN2559 is warranted by: an exhaustive worst-case error analysis; low component count; premium, field proven components; 100% burn-in of all ICs; CMOS digital circuits; generous derating margins; 100% testing of subassemblies; 4-day burn-in of all completed DPIs before final test; and a certified test and calibration report.

Study and compare 3¾-digit DPIs. Conclusively, with the value-added potential of the AN2559, Analogic offers the most versatile and flexible 3999 count DPI available for your present and future instrumentation requirements.

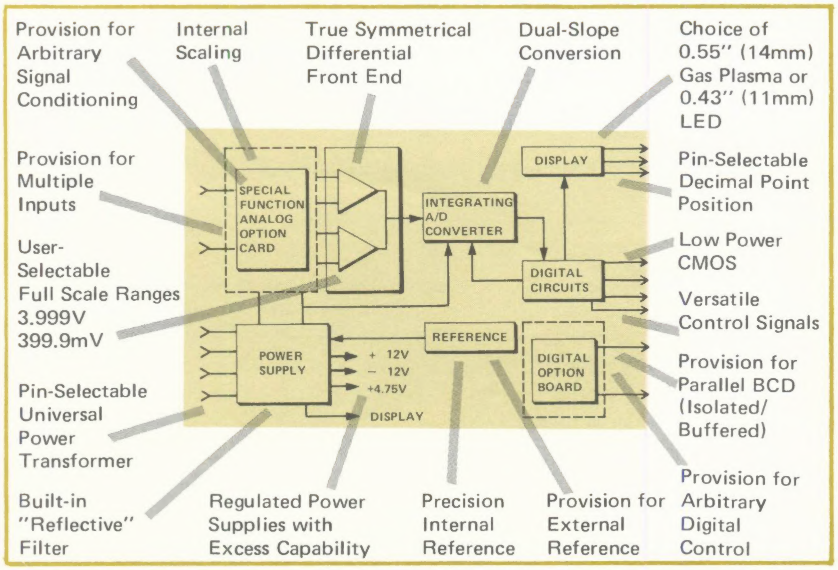


Figure 1. AN2559 Functional Block Diagram

FEATURES

INHERENT ACCURACY AND STABILITY
- Resolution: ±3999 counts
- Error: Less than ±0.05% rdg ±1 count
- Noise: Deadband less than 0.2 counts
- Temperature Coefficient: <35ppm/°C

DISPLAY OPTIONS
- 0.55" (14mm) Gas Plasma or 0.43" (11mm) LED
- Automatic polarity
- Pin-selectable decimal points

UTMOST RELIABILITY
- Low parts count
- Cool operation:
  - . . only 2 watts power consumption
  - . . low-power CMOS circuits
- Standard, proven, volume-production IC chips
- Dummy Zeros

USE-ORIENTED INPUT CONDITIONING
- True-differential, balanced symmetrical inputs
- Low bias current
- High input impedance
- Built-in signal offsetting capability

VERSATILE CONTROLS
- Built-in offset and range adjustments
- External run/hold
- Remote display control
- User-selectable full scale range

UNIVERSAL POWERING
- Universal power transformer; pin connectable for 100, 117, 220, or 240Vac, 49 to 500Hz
- Highly regulated internal supply voltages with excess capability

PROVEN INTERFERENCE REJECTION
- High CMRR and NMRR capabilities
- Built-in "reflective" line filter

ADAPTABLE MECHANICAL PROVISIONS
- International DIN and NEMA standard case
- UL 94V-0 Rated Plastic Case.
- Front-panel removeable, easily serviced
- Optional analog and digital function cards — quickly added-in

WIDE ENVIRONMENTAL RANGE
- Operating temperature range: −10° C to +60° C
- High rejection of electric fields
- Operational under harsh shock and vibration stresses

OEM INSTRUMENT-TO-PRODUCT TRANSFORMATIONS

By plug-in PC cards for thermocouple and RTD temperature indicators; pH meters; load cell, bridge, and LVDT weight, force, and pressure instrumentation

SYSTEM-COUPLING OF ANALOG INPUTS AND DIGITAL OUTPUTS

Low input bias currents: to fractions of picoamperes!

Very high impedance input circuits: to 10^{12} ohms!

Isolated and/or buffered parallel BCD outputs optional

Power-sharing and coupling capabilities

ANALOGIC®

. . . The Digitizers

AN2559 SPECIFICATIONS

ANALOG INPUT

		ADDED EXPANSION CAPABILITIES
Configuration	Bipolar balanced symmetrical differential inputs	Any arbitrary input transducer signal conditioning, plus filtering, amplifying, impedance-matching, and analog linearizing, etc.
Full-Scale Range	3.999Vdc or 399.9mVdc, user-selectable (special scaling available in OEM-quantity)	Any arbitrary input signal scaling
Bias Current	10nA nominal, 30nA maximum	As low as 10^{-13} amperes
Offset Current	5nA nominal, 10nA maximum	As low as 10^{-13} amperes
Dynamic Input Impedance	1000 megohms nominal	As high as 10^{12} ohms
Normal Mode Rejection	>40dB @ 50/60Hz with standard hi-freq. filter Up to 100dB with optional lo-freq. filter	Up to 100dB
Common Mode Rejection		
Isolated Digital I/O: CMV Range:	±500Vdc or peak ac	
CMRR:	>80dB (See Application Data)	Up to 160dB
Non-Isolated Digital I/O: CMV Range:	±(4.5V dc or peak ac minus input Voltage)	
CMRR:	>80dB @ 50/60Hz	
Zero-Offsetting	±30 counts nominal at 1-volt full scale	Any arbitrary value consistent with maximum input voltage specifications
Maximum Differential Input Voltage	±20V without damage	Up to ±1000V without damage

ACCURACY/STABILITY

Accuracy	±0.05% of reading ±1 count	
Resolution	±3999-counts	
Monotonicity	Guaranteed	
Range Tempco	35ppm of reading/°C typical, 70ppm of reading/°C maximum	
Offset Tempco	20μV/°C typical	
Recommended Recalibration Interval	12 months	

CONVERSION

Technique	Dual-slope integration, each measurement independent of the previous measurement	
Control	Displayed conversion controlled by internal (clock) or external (arbitrary system-developed control logic) command (low level applied to Pin 6 of Connector J1)	Built-in, arbitrary system-developed control logic (See Application Data, p.4)
Rate	~2 readings/second (internal) or any lower rate controlled by external command	Any arbitrary rate less than 2 readings/second, controlled by built-in logic command (See Application Data, p.4)
Input Integration Period	100 milliseconds nominal	

DISPLAY

Type	7-segment gas plasma, 0.55" (14mm) or LED 0.43" (11mm) nominal height, planar
Number of Digits	4 full-decade digits (See Ordering Code, p.3, for dummy zero options.)
Decimal Point	Externally programmable in three positions (See Application Data)
Polarity	Automatic plus and minus signs displayed
Overload (More Than 3999 Counts)	All digits blanked; polarity and decimal point remain illuminated

DIGITAL SIGNALS

(See Timing Diagram, Fig. 3.)

Logic Levels (All Inputs and Outputs)	DTL/TTL/CMOS compatible. Sinks 1.6mA at low level (0 to 0.4V) and sources 40μA at high level (+3.5 ±1V)
External Blanking	Low level input (on Pin 7) blanks all digits
Hold	Low level input (on Pin 6) retains last reading in display (See Fig. 7)
Overload	Low level output (on Pin 7) indicates a measurement greater than 3999 counts
Clock	Continuous (100kHz nominal) on Pin H
Latch	High level output (on Pin J) indicates that counter contents are being transferred into latches
Carry	Rising edge (on Pin F) indicates counter carry (See Application Data)
EOC	Rising edge (on Pin K) signals end of conversion (EOC)
Polarity	High logic level (on Pin 8) indicates measurement is negative

BCD OPTION CARDS	Isolated and/or buffered parallel BCD outputs (See Application Data, p.4.)
MTBF	43,000 hours, calculated

POWER

Input Voltage	100, 117, 220, or 240Vac rms ±10%, 49 to 500Hz	Excess powering such as +4.75Vdc, ±12Vdc ±8% at 10mA or −12Vdc ±8% at 10mA (See Application Data)
Available Output Voltage	+4.75Vdc ±5% at 30mA	
Consumption	2 watts nominal, slightly higher with LED displays	

ENVIRONMENTAL, PHYSICAL

Operating Temperature Range	−10°C to +60°C
Storage Temperature Range	−25°C to +85°C
Relative Humidity	0 to 95%, noncondensing
Weight	12 ounces nominal (340.2 grams)
Case	High-impact molded plastic, standard; metal case, optional
Dimensions	DIN-Standard: 96mm (3.78 inches) bezel width x 48mm (1.89 inches) bezel height x 104.9mm (4.13)

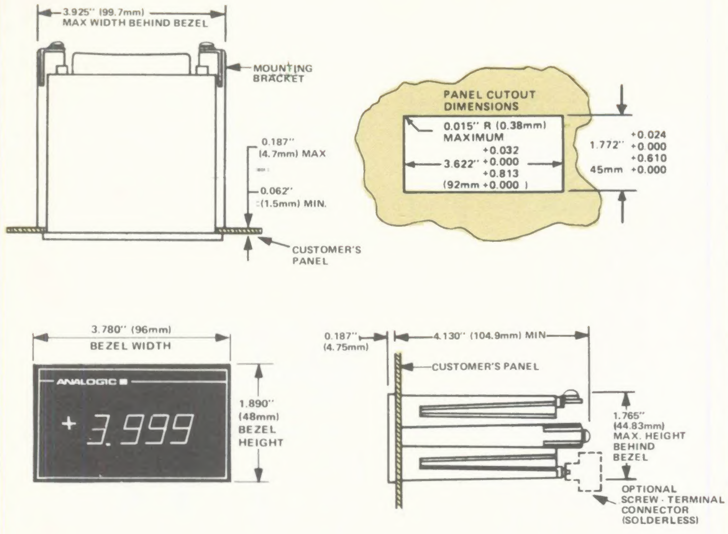


Figure 8. Panel Mounting and Outline Dimensions

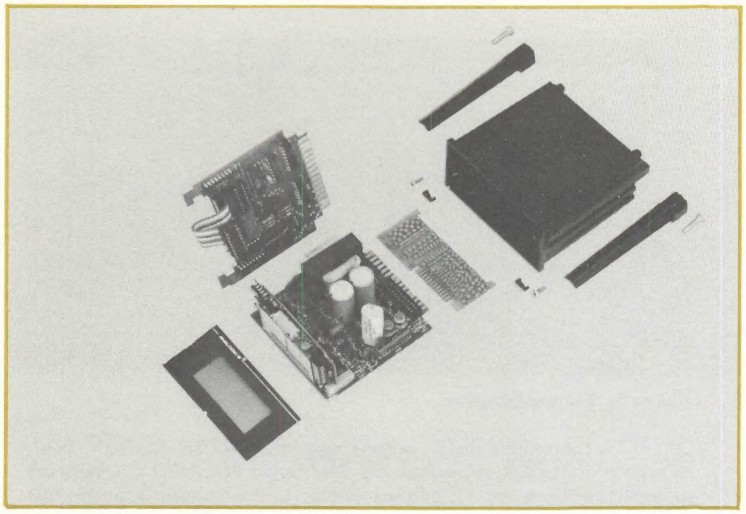
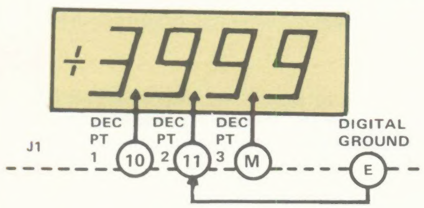


Figure 9. Complete DPI and Function Cards

DECIMAL POINT SELECTION



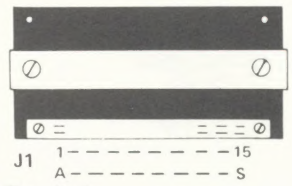
To display the desired decimal point, simply connect the appropriate pin as shown to the Digital Ground (Pin E, J1) using a jumper lead.

Figure 10. AN2559 Decimal Point Connections

Rear View – Bezel Not Shown for Clarity

A. Standard Card-Edge Connector (Solderable)

PL10-5563



B. Optional Screw-Terminal Connector (Solderless)

PL10-5535

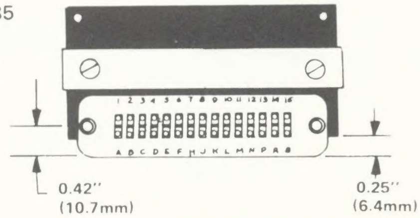


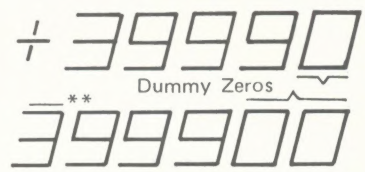
Figure 11. Rear Panel Connectors (Metal Case Option Shown).

For LED Displays only, either one (1DZL) or two (2DZL) "dummy" zeros may be added to the right end of the digital readout. These zero digits are "fixed"; that is, they always display "0" (1DZL) or "00" (2DZL) for all input signals within the specified range. See below.

Specify / For — 3999 Range

–1DZL*

–2DZL*



* Add to end of Order Code. Factory installation only.

** For positive inputs, negative sign does not light. For overload inputs, decimal point and middle horizontal segments of dummy zeros are lit; negtaive sign lights for negative overload only.

Figure 12. "Dummy" Zero Display

NEED APPLICATIONS HELP?

CONSULT NEAREST ANALOGIC SALES OFFICE OR REPRESENTATIVE.

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Houston, Texas (713) 777-6360

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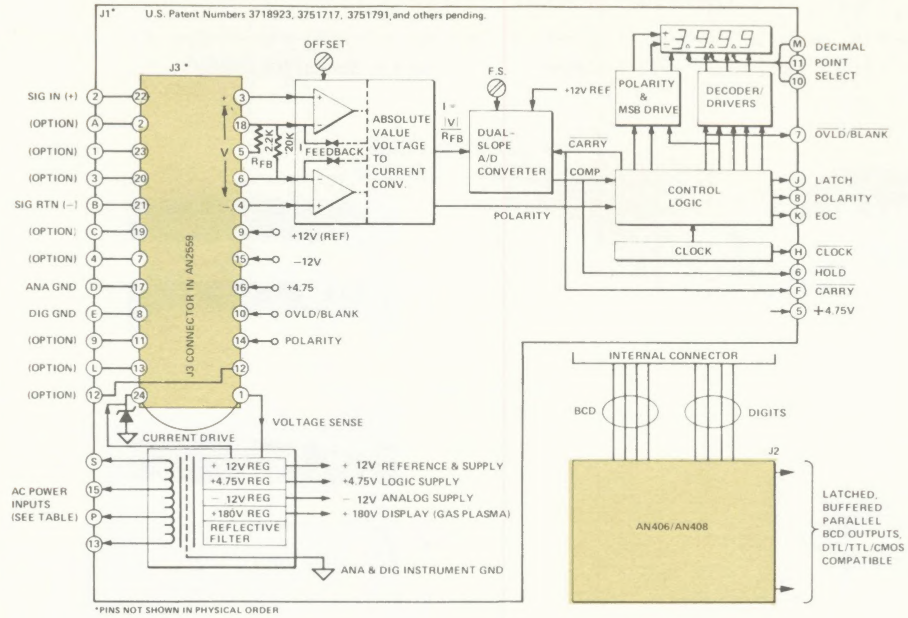


Pin Designations
J1 (Bottom of Case)[1]

ANA OPT[2]	A	1	ANA OPT[2]
SIG RTN (−)[2]	B	2	SIG INPUT (+)[2]
ANA OPT[2]	C	3	ANA OPT[2]
ANA GND	D	4	ANA OPT[2]
DIG GND	E	5	+4.75V OUT
CARRY	F	6	HOLD
CLOCK	H	7	BLANK IN/OVLD OUT
LATCH	J	8	POLARITY
EOC	K	9	DIG OPT[2]
DIG OPT[2]	L	10	DEC PT 1
DEC PT 3	M	11	DEC PT 2
DIG OPT	N	12	DIG OPT[2]
AC LINE[3]	P	13	AC LINE[3]
DIG OPT	R	14	DIG OPT
AC LINE[3]	S	15	AC LINE[3]

[1] Connector PL10-5563
[2] Available for user selection with Special Function card.
[3] See chart for power transformer connections.

TRANSFORMER CONNECTIONS

LINE VOLTAGE*	P	13	S	15
100V	●			●
117V (120)	●		●	
220V		●		●
237V (240)		●	●	

*49 to 500Hz

Figure 2. Simplified Schematic Diagram of AN2559.

Principles of Operation

As shown in Figure 2, the AN2559 contains a floating true differential front end; an absolute-voltage-to-current converter; a dual slope ratiometric, current-to-count integrating analog-to-digital converter; clock-driven logic control circuits, decoders, drivers, and displays; and regulated power supplies derived from secondary windings of the universal transformer.

Signal input to connector J1 is conditioned by arbitrary signal conditioning on the analog option card inserted in internal connector J3, resulting in a potential difference (V) at J3, Pins 3 and 4, connected to the non-inverting inputs of the differential input amplifiers. The conditioned signal input (V) develops a unidirectional signal current (I) whose magnitude depends on the value of the selected feedback resistance (R_{FB}), according to the simple Ohm's Law formula shown in Figure 2. The signal current linearly charges a high quality, low leakage, integrating capacitor during the signal integration phase of the dual-slope conversion. The current generation circuit also includes the polarity sensing for display.

Under control of the 100 kHz clock-driven logic, the signal integration phase lasts 10,000 counts, thus adding to the overall signal enhancement by providing very high rejection of normal mode interfering noise. At the end of the 10,000 counts, the $\overline{\text{CARRY}}$ control signal causes the integrator to switch into the reference integration phase, during which the integrating capacitor is discharged at a constant rate determined by a current derived from the precision +12V Reference until the Comparator changes state. The precision resistor network determining the integrating reference current is mounted on the same substrate as the built-in selectable feedback resistance. Thus maximum thermal tracking of ratio-determining dual-slope performance components contributes to the exceptional overall thermal stability of the conversion. Moreover, because the signal integration phase is at least 2.5 times as long as the reference integration phase (10,000 counts to a maximum of 3,999 counts), noise disturbances are reduced significantly in the output.

The count accumulated during the reference integration phase is latched into the storage register, decoded, and in addition to the polarity sensed in the current generator, used to update the display about twice a second for optimal flicker-free readings. When the count exceeds 3999, the digital Control Logic generates an overload (OVLD) signal which blanks the decimal digits while leaving the polarity and the selected decimal point illuminated.

In addition to decimal point programming the user may blank all four digits or may choose to Hold a displayed conversion by applying DTL-compatible signals at the designated terminals of J1. Note that the instrument continues to update its digitized measurement, making available a valid display after the Hold is released.

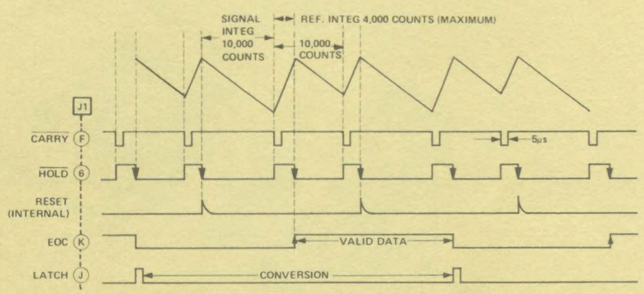


Figure 3. Timing Diagram

DTL/TTL-compatible digital output signals of LATCH, $\overline{\text{CARRY}}$, EOC, $\overline{\text{HOLD}}$, and $\overline{\text{CLOCK}}$, as well as the $\overline{\text{OVLD}}$ and POLARITY signals, are available at connector J1, and are related to the charge-discharge cycle of the integrating capacitor as shown in the timing diagram of Figure 3.

Analog Function Card
Connector J3, when utilized, brings to the analog function card a number of input signal connections, all power sources, and their ground return references for use in such signal conditioning circuits as described in the Application Data.

Digital Function Card
There is an excess of +4.75 volts to power the snap-in digital option card on which isolated and/or buffered BCD outputs are generated. Connections are made via the standard panel instrument connectors. See Application Data, p.6.)

ORDERING CODE

For Basic DPI — **AN2559** -☐-☐-☐

LED Display	**L**
Gas Plasma Display	**S**
Plastic DIN/NEMA Case PL10-5563 Connector	**P**
Extruded Aluminum DIN/NEMA Case with PL10-5563 Connector*	**M**
One Dummy Zero (LED Only)	**1DZL**
Two Dummy Zeros (LED Only)	**2DZL**

*Optional Screw-Terminal Connector, Analogic PL10-5535 available for solderless wiring.

APPLICATION DATA

INPUT SIGNAL ENHANCEMENT & INTERFERENCE REJECTION

The AN2559 exceptional overall signal interference rejection is a combination of:

(1) The intrinsic front end (input terminal related) CMR,
(2) The normal mode input filter rejection, and
(3) The long-time integration in the dual-slope A/D converter.

As a result, the user has a remarkable flexibility in obtaining accurate normal mode (series) noise rejection.

TRUE, BALANCED, DIFFERENTIAL INPUT & CMR

The high impedance, **true balanced symmetrical,** differential front end (not to be confused with some pseudo-differential types) provides the user with the versatility for making direct additive or subtractive measurements of local or remote noisy inputs from one or more sources, referenced to arbitrary system power or instrument ground. The digitized output represents the true difference of input potentials; therefore, it is insensitive (see specifications) to voltage variations and fluctuations **common** to both terminals. The input differential circuit itself can contribute to the rejection of common mode potentials referred to instrument ground. In addition, because of the high degree of isolation of the power transformer, excellent rejection ratios are achieved for common mode voltages up to ±350V with respect to power line ground.

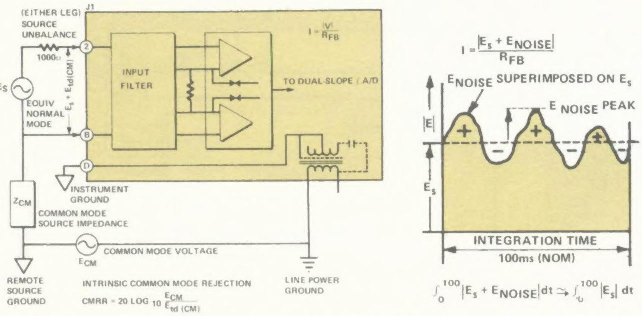


Figure 4. Transformation of Common Mode Signals (E_{CM}) to Normal Mode Signals ($E_{td(CM)}$, NMR) and Rejection by Integration

NORMAL MODE REJECTION

Normal mode interference signals, resulting either from conversion of common mode voltage to differential voltage or from additive (series) interferences, may be filtered out by a combination of passive or active input filtering and conversion integration. The AN2559 yields approximately 40dB rejection at 50/60Hz. There is ample provision within the AN2559 to incorporate low frequency and multipole passive filters and/or active filters, which utilize the input differential amplifiers as their active elements (see Example A, page 5), to obtain normal mode rejections up to 100dB or greater at 50/60Hz.

INTERFERENCE REJECTION BY INTEGRATION

Remaining interference components (after front-end terminal related and input filter rejection) are still further reduced by the 100-ms integration period. For net signal level-to-peak noise ratios higher than one, the bipolar integration is complete so that, even for non-synchronous 50 or 60Hz interference, rejection greater than 20dB will be achieved.

Overall common mode rejection ratios of greater than 160dB (for example, 80dB CMRR, +60dB NMRR, +20dB integration rejection) at 50 or 60Hz with a 1000-ohm unbalance in either input line can **readily** be obtained!!

ANALOG FUNCTION CARD

Using either the Analogic AN451 General Purpose Analog Function Card (shown on page 6), which is typically capable of handling 30 arbitrary components, including potentiometers, dual in-line ICs, and discrete 2-and 3-lead components, or by designing his own such card, the user may build in proprietary circuits for any arbitrary signal conditioning, excitation, or linearizing function, utilizing the available excess regulated power, stable reference, and additional input terminals for optimum system compatibility.

The general purpose analog function card (kluge card), with a pre-engineered layout for optimum component space utilization, is held securely in the DPI by connector and case without need for any additional mounting hardware.

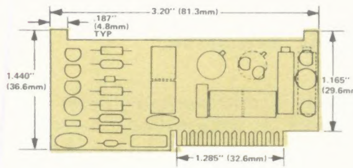


Figure 5. Typical "Kluge" Card Layout

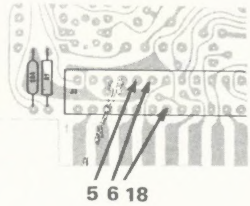


Figure 6. PC-Board Scaling Connections

ARBITRARY SCALING

With a 20,000Ω feedback resistor (R_{FB}) connected as shown in Figure 2, the DPI is normally calibrated at the factory for a full-scale range of 4 volts/4,000 counts. A thermally tracking internal resistor (2,200 Ω) may be connected in parallel with the 20,000-ohm resistor by connecting pins 5 and 6 on J3. See Figure 6. The parallel resistance of 2000 ohms provides the user-selectable sensitivity of 100mV/1,000 counts (100μV/count).

Any other sensitivity may be obtained by a net resistance between pins 6 and 18 according to the formula $R = \frac{\text{Voltage/1,000 Counts.}}{0.05\text{mA}}$

HOLD

To hold a displayed reading, gate a HOLD command (the comparator output shown in Figure 2) with the rising edge of EOC (available at J1, Pin K). Then, generate a DTL low level signal ($\overline{\text{HOLD}}$). When applied to Pin 6 of J1, the HOLD signal will keep the last conversion displayed, while the DPI continues to update the measurement internally. When HOLD is removed, the next valid measurement is transferred to the display latches.

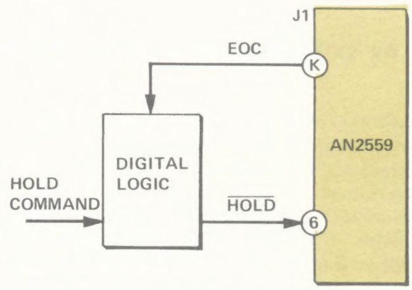


Figure 7. Generating a HOLD Command

ANALOGIC LIBRARY OF SPECIAL FUNCTION CARDS

DIGITAL CIRCUIT OPTIONS

AN404	Function PC Card DIN Standard
AN406	Latched, Buffered Parallel BCD Output Card
AN408	Isolated, Buffered Parallel BCD Output Card

ANALOG CIRCUIT OPTIONS

AN450	Analog Function PC Card with Input Filter
AN451	Analog Function PC Card without Input Filter
AN452	Thermocouple Cold-Junction Compensation Card
AN453	RTD Temperature Card
AN454	Input Filter Card
AN455	Industrial Current Receiver Card
AN456	Industrial Voltage Receiver Card
AN461	True RMS AC Voltmeter Card
AN462	Power Line Voltage Monitor Card
AN463	Microvolt Receiver Card
AN466	Linearized Thermocouple Card

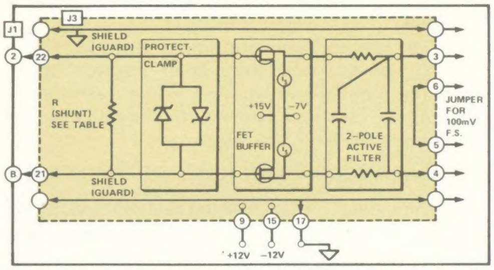
APPLICATION DATA

The examples below are only a few of the essentially limitless applications of the AN2559. They indicate the wide range of applications, versatility, and ease of using this digital panel instrument.

Assemble A Precision Current Meter

F.S. RANGE	UNIT COUNT	SHUNT, R
2.000 Amp	1mA	0.100Ω
200.0mA	100μA	1.000Ω
20.00mA	10μA	10.00Ω
2.000mA	1μA	100.0Ω
200.0μA	100nA	1.000KΩ
20.00μA	10nA	10.00KΩ
2.000μA	1nA	100.0KΩ
200.0nA	100pA	1.000MΩ
20.00nA	10pA	10.00MΩ
2.000nA	1pA	100.0MΩ

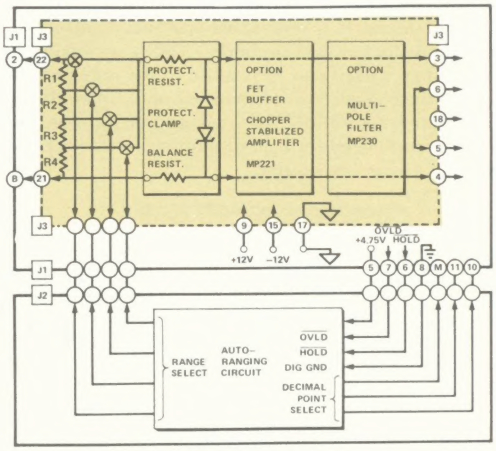
To measure current from amperes to picoamperes, simply select the standard 100mV/1,000 count DPI sensitivity and install the appropriate shunt resistance. Depending on the signal amplitudes and interferences, design protective clamps, low leakage FET buffers, and multipole filters. Appropriately guard for higher sensitivity operation by eliminating leakage current paths. Digitize the output in any arbitrary engineering units by modifying the shunt resistance between Pins 6 and 18 of J3. By connecting either end of the shunt to analog ground, or by other means, assure circuit conformance to common mode limits.



Build An Extended Range Voltmeter

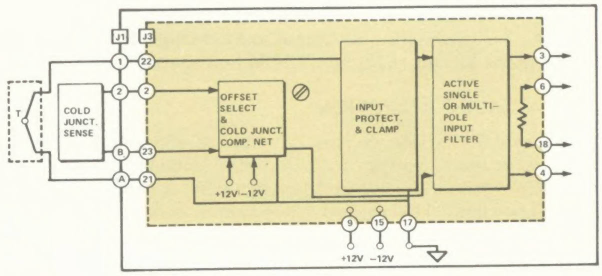
To measure any voltage from kilovolts to microvolts, use either of the selectable standard DPI sensitivities and the appropriate voltage divider network. Depending upon whether a single-range or multiple-range voltmeter is desired, design suitable switching circuits to be activated either by externally programmed range select signals, or optionally, by range control signals developed on the digital function card. Protect the input circuits with resistive and clamping components, and introduce an optional FET buffer, a chopper stabilized amplifier, or a standard amplifier module, such as the Analogic MP221, if needed in very low level signal applications. Incorporate an optimal filter to obtain the necessary signal enhancement. Measured voltages may be scaled in arbitrary engineering units by suitable modifications to the input divider network alone, or coupled with the appropriate scaling resistors (R_{FB}).

	SINGLE-RANGE			MULTIPLE-RANGE	
	1000V	100V	10V	EITHER	
R1	999K	990K	900K	9M	900K
R2	1K	10K	100K	900K	90K
R3	0	0	0	90K	9K
R4	0	0	0	10K	1K



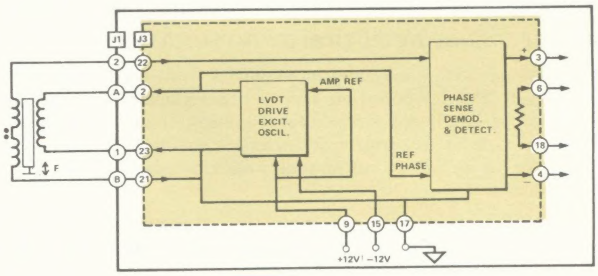
Construct A Thermocouple Temperature Indicator

Cold-junction-compensated temperature indicators, utilizing any type of thermocouple, with excellent common mode (greater than 160dB!) and normal mode (greater than 100dB!) rejections can easily be constructed with just a few components. A semiconductor or a resistive cold junction sensing element, stably powered by the DPI +12V power reference, can generate an offset and cold-junction-compensation variable voltage which can be directly subtracted (or added) from the thermocouple-developed voltage via the true differential balanced input circuit. Input resistor and zener clamps may provide protection, and filter components as shown in "A" above may form an active two-pole filter. The appropriate resistor across Pins 6 and 18 of J3 scales the output directly in temperature-related engineering units.



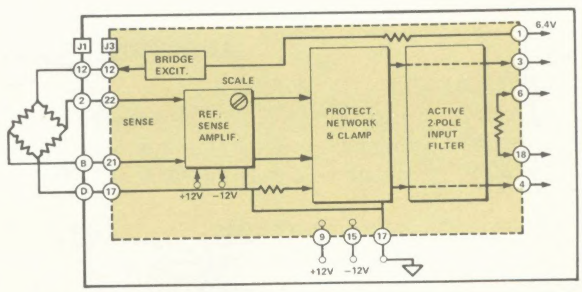
Develop An LVDT Position Or Force Indicator

The excitation winding of an LVDT may be driven over a wide range of frequencies by an excitation oscillator powered by the +12V regulated supplies and amplitude regulated by the precision +12V supply. The combined differential winding output of the LVDT can then be phase-sensitive-demodulated in a simple switching circuit whose phase reference is derived from the excitation oscillator. The filter output of the phase sensitive demodulator can then be applied directly to the differential inputs of the DPI. Again, the output may be scaled in any desired force or linear units by choosing the appropriate resistor across Pins 6 and 18 of J3.



Engineer A Ratiometric Load Cell Meter

The ratiometric capability of the AN2559 may be exploited to perform ratiometric measurements of bridge transducer outputs with an accuracy independent of the excitation supply variations. Available input pins may be utilized to sense the voltage across the bridge via a reference sense amplifier whose output may be applied via Analog Function Card Connector J3, Pin 1, to control the DPI reference. The differential output of the bridge may be scaled, offset, or amplified, or may be applied directly to the differential inputs. As described above, the scaling resistor between Pins 6 and 18 of J3 converts to arbitrary engineering units.



Analogic Application Engineers would be pleased to provide additional examples and assistance to OEM users.